

Ceramic's Influence on Chinese Bronze Development



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Photos on cover page

<p><i>Jue</i> from late Shang period decorated with whorl and thunder patterns and taotie creatures, H: 20.3 cm [34].</p>	<p>Painted clay <i>gang</i> with bird, fish and axe design from the Neolithic Yangshao culture, H: 47 cm [14].</p>
<p><i>Pou</i> vessel from late Shang period decorated with taotie creatures and thunder patterns, H: 24.5 cm [34].</p>	<p>Flat-based <i>jue</i> from early Shang culture decorated with taotie beasts. This vessel is characteristic of the Erligang period, H: 14 cm [34].</p>

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The transition from the Neolithic pottery making to the emergence of metalworking around 2000 BC held significant importance for the Chinese metal workers. Chinese techniques sharply contrasted with the Middle Eastern and European bronze development that relied on annealing, cold working and hammering. The bronze alloys were difficult to shape by hammering due to the alloy combination of the natural ores found in China. Furthermore, China had an abundance of clay and loess materials and the Chinese had spent the Neolithic period working with and mastering clay, to the point that it has been said that bronze casting was made possible only because the bronze makers had access to superior ceramic technology. The progress made in bronze casting due to improved process planning, refining and experimenting with vessel form and decoration were skills developed during the Neolithic Period. Advances in ceramic technology played an influential role in the evolution of Chinese bronze casting where the piece mold process was more of a technological extension of their achievements than a distinct innovation.

Approximate Timeline

Neolithic Period (8000-1700) BC

- Yangshao culture (5000-3000) BC
- Hongshan culture (4700-2500) BC
- Dawenkou culture (4300-2500) BC
- Liangzhu culture (3300-2200) BC
- Majiayao culture (3100-2700) BC
- Longshan culture (2600-2000) BC
- Qijia culture (2400 – 1900) BC

Xia (2100-1600) BC

- Erlitou culture (1900-1600) BC

Ba (2000-220) BC

Bronze Age (1766-121) BC

Shang (1700-1100) BC

- Zhengzhou phase (1600-1400) BC
- Erligang culture (1500-1300) BC
- Anyang phase (1300-1100) BC
- Yinxu culture (1200-1050) BC

Zhou (1100-256) BC

- Western Zhou (1100-771) BC
- Eastern Zhou (770-256) BC
- Spring and Autumn period (770-476) BC

Warring States Period (475-221) BC

Qin (221-206) BC

Han 206BC-200AD

Tang (618-906) AD

Introduction

One of the greatest archaeological discoveries of this century occurred in March 1974, near the city of Xi'an in the province of Shaanxi. Farmers digging for water unearthed part of a clay object. This activity led to the eventual excavation of the terracotta army of Emperor Qin Shihuangdi from several underground vaults. Among the contents of these excavation pits were wooden chariots, thousands of soldiers, bronze weapons and horses [1]. The wealth of historic possibility found in these earthen pits, though incredible, was just a small part of the immense (56 sq. kilometer) underground empire. The First Emperor, who ruled between 246 and 210 BC, had centralized control and formed a huge court bureaucracy to administer his empire. Qin Shihuangdi united the Chinese with one written language, standardized weights, measures, writing scripts, money, roads and even the axle widths of chariots. His most ambitious building projects included work on the first Great Wall (meant to keep out foreign invaders) and his own mausoleum where as many as 700,000 workers labored to build his palace for the afterlife [1]. Thousands of peasants and craftsmen labored in its creation for nearly 40 years. The excavated pits had been looted and all the clay figures broken, apparently by the conquering troops of the Han, soon after completion. Excavating them has been a massive undertaking and more than a thousand warriors have been reassembled [1]. The beginnings of the Chinese culture, however, began many thousands of years prior to Emperor Shihuangdi.

More than 2500 years passed between the advent of metal casting in the Yangshao culture (roughly 5000 BC) and the beginnings of the Bronze Age [2]. The transition from Neolithic pottery to the emergence of metalworking (around 2000 BC) was significant for the Chinese metal workers whose techniques sharply contrasted with the Middle Eastern and European bronze development that relied on annealing, cold working and hammering. Natural resources greatly influenced the choices made by the Chinese. The types of copper ores that are native to China are not malleable; the bronze alloys were difficult to shape by hammering. China has large amounts of clay and loess (a yellowish-brown colored silt, the Chinese refer to as yellow earth). The Chinese were adept at working with clay. Advances in ceramic technology played an influential role in the progress of Chinese bronze casting where the piece mold process was more of a technological extension than a distinct innovation.

Before the invention of the potter's wheel, vessels were formed by hand. Clay was coiled into ropes and then carefully smoothed using tools on the exterior and inside wall. Neolithic pots were fired in kilns dug in the ground. Yangshao kilns had pierced floors to allow better circulation of heat and air [1]. Invention of the fast wheel, around 3000 B.C. by the Dawenkou and Longshan cultures, meant that potters could make thin-walled, evenly formed vessels, and with greater speed. Later, some pottery shapes were mass produced using molds. The idea of heating clay to harden probably came about after raw clay had been left next to a hearth. Firing within a confined space (kiln) permitted further experimentation with different firing temperatures, raw materials and decoration. The development of freestanding kilns in the Bronze Age led to higher temperatures and stronger vessels. Shapes became more refined and eventually, glazes were added that made the clay impermeable to liquids [1].

Prior to the discoveries made in the late 20th century, Chinese civilization was thought to have developed in the Central Plains (Zhongyuan) area of the Yellow River (Huang He). The Yellow River Valley (Figures 1-2) was heavily excavated in the 1950s to prepare for national infrastructure construction projects and the Sanmenxia Yellow River Reservoir. The shapes of bronze vessels were also dependent on clay prototypes. The Yellow River picks up silt (loess) in the region where it flows south from the Ordos Desert (Figure 2), hence its yellow color. The silt settles in the river bed, causing the water level to rise over time. As a result, flooding is common [3, 4]. It was in this area that ancient sites of the Yangshao were unearthed. Major areas of excavation have been undertaken in Sichuan (Sanxingdui), Shaanxi (Xi'an), Shanxi (Houma foundry, Erlitou), Hebei, Shandong, Henan (Anyang, Zengzhou, Erligang, Erlitou) Chongqing and Hubei, areas previously thought to be lacking historical context. The map of the Chinese provinces (Figure 3) shows the extensive excavation done subsequent to the 1950s and the vast cultural remains unearthed from several of the sites.



Figure 1: Map of Chinese provinces [5].

Neolithic Culture

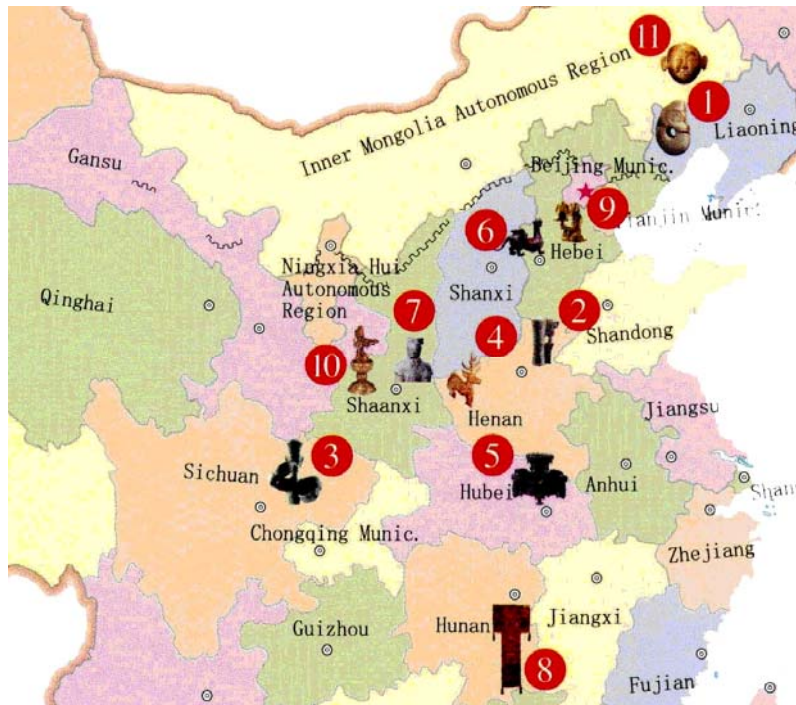
The Neolithic period is most typically associated with a prehistoric culture and the emergence of agriculture, animal domestication, sedentary farms and villages. This perception has been revised over the last century with the archaeological findings of polished stone axes. As well, it was realized that the definition of this period based on a single artifact type was not highly accurate, nor representative of the culture. Neolithic people were characterized by the chipped stone tools that were excavated. Subsequently, a more comprehensive view was developed that incorporated pottery manufacture, agriculture, livestock, and settled villages, but did not yet use alloyed metals [6]. More than 7000 Neolithic sites have been discovered (Figure 4), providing evidence to corroborate cultural diversity and multiple origins for the Chinese civilization [3].



Figure 2: a) The Yellow River, near Xunhua, in Eastern Qinghai [7]; b) the Huang He (Yellow River) travels through roughly 4672 km (2903 miles) from its source in the Kunlun Mountains to its mouth on the Bo Hai gulf [3-4].

Archaeologists have recorded the material remains from a number of distinct regional cultures dating to roughly 6000-5000 BC. These Neolithic cultures developed following the introduction of agriculture, the earliest traces dating as far back as 8000 BC. The cultivation of plants and the domestication of animals lessened their dependence on hunting and gathering while providing a more settled lifestyle [8, 9].

These changes brought new social organization that eventually influenced material culture. Labor was divided, first at the household level, then more broadly within the community. This form of specialization led to the development of improved methods in pottery production, stone working and other technologies [10]. By 4000 BC, the archaeological record shows more indications of cross cultural contacts and influences. Knowledge was shared, but, with increased contact, defense also became more important, and eventually many communities were walled for protection. Building these defenses required greater coordination of resources and labor that contributed to social stratification [1].



- | | | |
|-------------------------------------|--|--------------------------------------|
| ① The Hongshan culture | ⑤ The tomb of the Marquis of Zeng | ⑧ The Han tombs at Mawangdui |
| ② Fuhao's tomb | ⑥ The tombs of the Prince of Zhongshan | ⑨ Han Dynasty Tombs at Mancheng |
| ③ Sanxingdui sacrificial pit | ⑦ Terracotta figures of warriors and horses at the Qinshihuang Mausoleum | ⑩ Underground palace at Famen Temple |
| ④ Burial ground of the State of Guo | | ⑪ Tomb of the Princess of Chen |

Figure 3: The map of Chinese provinces shows the location of numerous excavation sites [11].

Evidence of brass metallurgy can be traced back to the early fifth millennium BC at a Yangshao culture site in the Guanzhong region of Shaanxi province. Bronze-working, evidenced by knives found at the Majiayao culture site (Gansu province), in the upper reaches of the Yellow River, had developed by late fourth or early third millennium BC [2]. Rings made of arsenic bronze were recovered from a Hongshan culture site in western Liaoning province, dating to approximately the same period. In the middle reaches of the Yellow River, sites of the Longshan culture have been found in Shaanxi, Shanxi and Henan provinces. Sites associated with the Henan Longshan culture have yielded fragments of molten lead bronze from furnace walls (Zhengzhou), fragments of molten copper from a stove bottom (Linru), and copper casting dregs (Huiyang). A copper bell was discovered in a Longshan culture tomb at Taosi in Shanxi province. In Shandong province, pieces of bronze, bronze casting dregs and brass awls were discovered in several counties.



Figure 4: There were numerous early Neolithic sites attributed to the predominant cultures; several sites are identified on the map: 1-Machang, 2-Banshan, 3-Majiayao, 4-Banpo, 5-Laoguantai, 6-Yuanjunmiao, 7-Jianzhai, 8-Lijiacun, 9-Miaodigou, 10-Yangshao, 11-Wanwan, 12-Dahecun, 13-Peiligang, 14-Cishan, 15-Yedian, 16-Yantai, 17-Dawenkou, 18-Liulin/Dadunzi, 19-Huating, 20-Donghaiyu, 21-Hongshan, 22-Niuheliang, 23-Songze, 24-Beiyinyangying, 25-Majiabang, 26-Hemudu, 27-Daxi, 28-Guanmiaoshan, 29-Huanchenggang, 30-Dapenkeng, 31-Fuguodun, 32-Chao'an, 33-Shenwan, 34-Xianrendong, 35-Zengpiyan, 36-Dalongshang, 37-Qianshanyang [11].

Yangshao is one of the earliest Neolithic cultures identified in China. It consisted of two broad regional groupings: a group around Henan province and another group around Shaanxi province. The urn (Chinese *gang*) seen in Figure 5 comes from the Henan Yangshao culture found south of the Yellow River. The Yangshao culture is often called the painted pottery culture; classification of pottery shapes and decorations is one means for archaeologists to identify cultural groupings. Yangshao vessels were typically decorated with geometric designs resembling plant or animal forms [1]. The decoration on this late Yangshao phase *gang* is more realistic than some of the earlier abstract depictions. Yangshao remained strongly connected to nature as demonstrated by the animal imagery on their vessels (fish, birds, frogs or turtles) [1, 8]. The Banpo site (Figure 4) was inhabited by the Yangshao culture in Shaanxi Province from 4800-4300 BC. The Archaeological Institute of the Chinese Academy of Social Sciences conducted five excavations at the ruins digging up more than 10,000 sq m from 1954 to 1957. The Banpo people primarily used wood and stone tools to make their pottery (Figure 5b) [11]. The flat-bottomed *lei* (Figure 5c) is believed to be from the Yangshao in the Gansu area. This beige colored earthenware has a very thin lipped opening that is delicately painted with black swirling cloud motifs.



Figure 5: Yangshao culture painted pottery: **a)** basin with human face and fish pattern from Banpo site; H: 16.7 cm, D: 39.7 cm [9, 11, 13]; **b)** urn (*gang*) decorated with a long-legged heron, fish and axe, (3500 BC-3000 BC), H: 47 cm, D: 32.7 cm, base: 19.5 cm, Henan Province, excavated in 1978 [1, 8, 13, 14]; **c)** *Lei* (flat bottomed storage jar), Neolithic to early Bronze (3000-1500 BC), H: 18.32 cm [15].

The unearthing of elaborate jade, ivory and bone objects from Dawenkou cultural burial sites confirms advanced skills for other technologies as well. A jade object, one of two found on the chest of a buried male (Figure 6) had a drill-hole suggesting that the object was suspended on a cord and worn by the dead man when buried. Fifteen years of excavations at Niuheliang have produced no other examples. It is assumed that the Hongshan culture highly valued jade and the buried man was a noble. Hongshan culture made use of metal casting technology; this assumption was made from a copper ring that was unearthed from a tomb at Niuheliang and 2 small molds excavated from the foundation of a house in Inner Mongolia (in 1987) [1]. Most objects were recovered from gravesites near the remains of ancient villages from the Hongshan, Yangshao, Liangzhu and Taosi Longshan cultures. The vast majority of finds at these sites were pottery vessels, some tools and other objects made of jade, bone and stone [1, 8].



Figure 6: **a)** photograph of excavated Tomb 4 at Niuheliang in Liaoning province. The jade coiled dragons can be seen on his chest [1]; **b)** Jade coiled dragon, Hongshan Culture (4700-2920 BC), Liaoning province [1].

The ruins of the Liangzhu culture, discovered in 1936, have been identified at approximately three hundred sites in northern Zhejiang province (distributed over 30 sq

km) and southern Jiangsu province in present day Shanghai [11]. Liangzhu cultures produced abundant rice harvests, and sites have yielded evidence of silk weaving, lacquering and some of the earliest use of mortise and tenon joints in timber construction. They are best known, however, for finely chiseled jade objects that were used as ornaments, ritual objects (Figure 7) and weapons. The well crafted jade is attributed to more sophisticated rotary tools. The *cong* seen in Figure 7b is among the most impressive and largest ancient jade excavated in Zhejiang province. The squared corners are usually decorated with designs resembling faces [1].



Figure 7: a) Carved jade ritual object from the Liangzhu Neolithic culture [12-13]; b) largest jade cong found, referred to as the “King of cong”, yellowish white jade, H: 8.8 cm; W: 17.6 cm; Wt: 6.5 kg; excavated in 1986 in Zhejiang province [11, 16].

The Majiayao cultures emerged from the Yangshao people in the western provinces of Gansu and Qinghai and are well known for their mass production of pottery. Characteristically, their artifacts include large pottery vessels decorated with spiral circles, undulating lines and geometric patterns painted in black, red and sometimes white (Figure 8). New archaeological research suggests that Majiayao painted pottery was influenced by Yangshao pottery designs from central China [13].

Longshan cultures were predominate in China's Central Plains during the late Neolithic period from about 3000 to 2000 BC. First identified in 1928 at the Longshan site in Shandong province, different regional Longshan cultures have since been found in Henan, Shanxi, Shaanxi, Hubei and Hunan. The pottery basin (Figure 8) comes from a burial at Taosi in southern Shanxi, a late Longshan site. The basin was fired at a low temperature (assumed from the discernible porosity), its decoration applied after firing [1, 8]. From the large number of artifacts (bronze and copper tools, lacquered wooden objects and animal bones) unearthed from Longshan settlements, it is clear that the people were already in an agricultural phase, planting cereal crops and breeding pigs, dogs, cattle and sheep. Some excavated objects contained pictographs that may be the earliest writing in China [1, 8]. There is evidence to support a belief that there was increased conflict during the Longshan period; the types of weapons (arrowheads, polished stone lance heads) grew, sites were fortified and there are the numerous rough graves of slain people. Warfare was a key process in the development of the Xia Dynasty [10]. A large grave site was discovered with many burial objects of stone and jade and painted pottery. From radiocarbon analysis, the Taosi culture is believed to have

coincided with the early period of the Xia Dynasty. The curled dragon on the dish in Figure 8b is the first painted dragon on a pottery vessel ever discovered in China [11].



Figure 8: a) Majiayao pottery vase; wavy lines and scroll patterns are dominant themes in this culture [13]; b) painted pottery pan basin, H: 8.8 cm, D: 37 cm, Taosi Longshan culture (2500-1900 BC), Shanxi Province, excavated in 1980 [11].

The Longshan culture discovered in Shandong developed from the Yangshao culture and had a wider geographical distribution around the Yellow River valley. Grey pottery was the main pottery ware for daily use (except in the Qijia culture). Variable colored pottery (such as grey, black and red) was produced by controlling the atmosphere inside the kiln. Some white pottery was also made with kaolin clay [17]. The Shandong Longshan cultures have provided confirmation of metallurgy (copper smelting) and technically sophisticated pottery and quartz kilns [10, 18]. These accomplishments were made possible with the pottery kiln developments and increased firing temperatures (from 850-950°C in 7000-5000 BC to 900-1000°C and sometimes as high as 1050°C in the Yangshao and Longshan) [8]. Their pottery production was more advanced and had evolved from hand forming to using a potter's wheel. Black eggshell ware with its thin body and high level of craftsmanship was surprisingly "sophisticated", "elegantly shaped" and used a high quality clay mixture. The "eggshell" refers to incredibly thin walled vessels, less than a millimeter at the rim (Figure 9), paper thin, yet they are durable and strong [9, 14, 17]. These Neolithic vessels are likely the prototypes for the bronze *gu* (goblet) that was popular during the Shang dynasty [10, 13]. Compared with the pottery of the Yangshao culture, significant changes in shape and design had occurred. Some archaeologists have proposed that the Bronze Age cultures (Xia, Shang and Zhou) in fact, each developed from separate branches of the Central Plain Longshan Culture [8, 17, 19].



Figure 9: Examples of Longshan period black eggshell pottery vessels **a)** high stemmed goblet; **b)** long stemmed *bei* goblet; **c)** shorter wide rimmed vessel [13].

Bronze Development

To provide context for the development of ancient Chinese bronzes, ceramic technology and jade carving in the late Neolithic period was examined. Little evidence of the primitive bronze castings has been found. There are not hoards of vessels to indicate that the Chinese required an extended period of time to transition from novice laborers to more adept bronze craftsmen. Though, it's possible the evidence was melted down and used in later castings. The formative years of the late Neolithic period (pre Bronze Age) help to explain the incredibly swift transition from primitive bronze work to the more skilled craftsmanship. Specialized techniques and skills as well as division of labor were used during the Bronze Age, but required years of experience for mastery of delicate inscriptions, decoration and handling clay [23]. Figure 10 shows the progression of ceramic and bronze alloy development resulting from new techniques, materials and designs. However, at the beginning, bronze artifacts were just copies of clay objects. The Chinese were improvising, they had discovered a new material (bronze alloys) and used it instead of clay. The results were objects that looked very similar to their clay predecessors. With the passing of time, the objects evolved into shapes more suitable for the bronze material.

Figure 11 shows direct evidence of the similarities between the clay objects and the bronze copies. Given China's natural resources, clay, jade and bronze were the dominant materials used by the ancient Chinese Bronze Age cultures [6, 9-10, 18-37]. Clay and bronze appear to have been closely linked throughout their historical developments. Both required knowledge of materials and dexterity to create the finished products. Both clay and bronze could be made into varied shaped containers for every day use [6, 9-10, 18-37]. Bronze, however, became a status symbol for wealthy Chinese aristocrats and was no longer possessed by the common people.

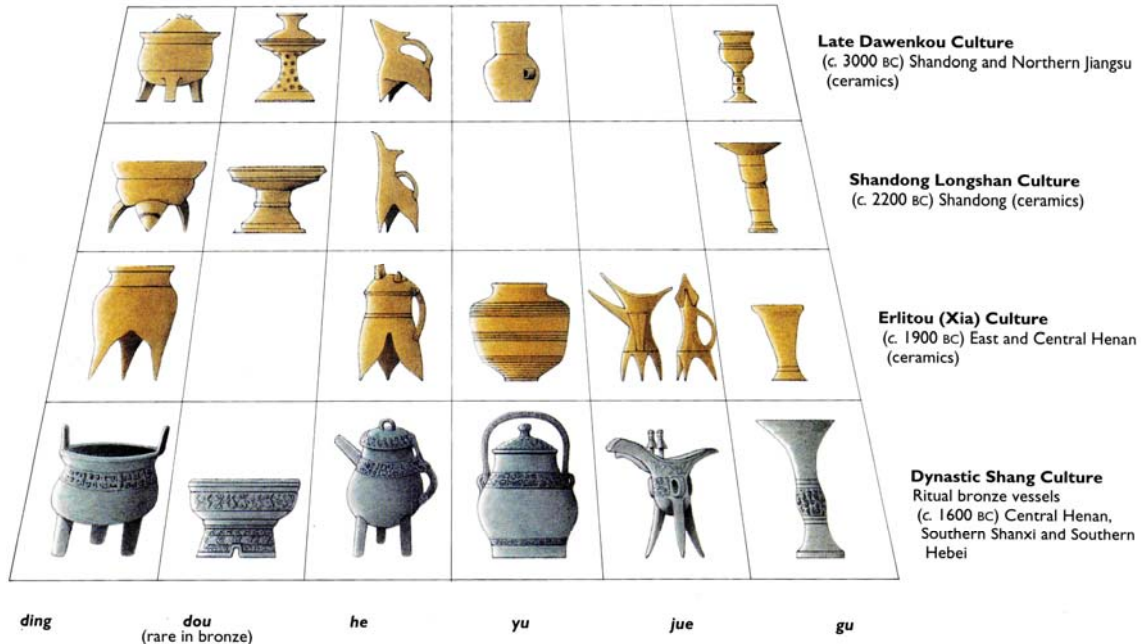


Figure 10: Evolution of Shang dynasty ritual bronze vessels from Neolithic ceramic prototypes [12].

Brass, copper, lead and tin bronze objects were manufactured over a wide geographic range and time span during Neolithic and Chalcolithic (copper) cultures. Archaeological discoveries confirm the likelihood of several origins of Chinese bronze cultures and suggest that bronze metallurgy did not have a single point of origin in China. As well, the use of bronze did not emerge or develop uniformly among the different cultures. Copper metallurgy objects began in the late Neolithic; they appeared occasionally in the Longshan culture and became more common in the Qijia. The oldest Chinese bronzes were found in the Gansu-Qinghai region near the Yellow River and attributed to the Qijia culture. This culture produced some of the earliest bronze and copper mirrors found in China; other Qijia sites have yielded copper, lead and tin bronze artifacts (knives, awls, axes, chisels, drill heads, rings and round boss ornaments) that have been forged and cast with single or composite molds, the techniques were fairly primitive. Though the Qijia used bronze, it was not the predominate material in their culture [2].

It is argued that the Yellow River Valley was the center for metallurgy in ancient China [8]. Evidence suggests that the Erlitou culture was not only the first culture to enter the Bronze Age, but that it quickly adopted highly advanced techniques for bronze casting. Bronzes from the Erlitou period include tools (knives, awls, saws and chisels), weapons (*ge* blades and *qi* axes) and the earliest known vessel types cast in sectional molds (*jue*, *jia*, *he* and *ding*). The Erlitou culture was concentrated in western Henan and southern Shanxi provinces (part of the Xia dynasty), yet reached the northern shore of the Yangzi River. The early remains from Sanxingdui in Sichuan province show influences of the Erlitou culture [2].



Figure 11: **a)** bronze wine vessel (Zuyi jiao), ~1000 BC, Shang dynasty, H: 23.9 cm, W: 18.6 cm, D: 10.9 cm [38]; **b)** Eastern Zhou bronze lei, 700 BC [39]; **c)** bronze lei, late Shang period, ~1300-1050 BC, H: 43.5 cm, D: 18.6 cm [40]; **d)** bronze cooking vessel (Fuxin ding), 1100 BC, Shang dynasty [38]; **e)** a pottery jiao vessel, ~2000-1500 BC [1]; **f)** Yangshao funerary jar (~2500 BC) earthenware with painted spiral décor, H: 37.15 cm x W: 40 cm. [41] **g)** white pottery lei jar, excavated from Anyang, Freer Gallery of Art, (1200 BC) [38]; **h)** pottery ding, cooking vessel of Xia dynasty, 20.5 cm high, rim 20 cm diameter; unearthed at Erlitou [42].

The Sanxingdui culture that has provided some of the most unique bronze work, seemingly unrelated to their contemporaries in subject matter or style, used the same casting techniques as the Erlitou (Figure 12). The Erlitou had the power and the ability to organize and gather raw materials from neighboring areas by force and to commission manufactured goods from skilled artisans [2]. Figure 13 shows several very primitive Erlitou bronze castings with clumsy workmanship, uneven surfaces, visible casting residues and noticeable seams. Figure 13b has a shape that is derived from pottery models common in the Neolithic, with little or no decoration, which is very typical of the Erlitou culture. Figure 13c shows more skilled workmanship having been created during the Shang period when Fu Hao was queen (roughly 500 years later).

The early Shang culture developed by assimilating advanced elements of the Xia culture (from the Erligang site in Zhengzhou city, Henan province). Bronzes recovered from Erligang (Figure 14) confirm the technical achievements of the early Shang culture and its advances in bronze casting. The quantity of bronzes unearthed from early (Zhengzhou) Shang sites attests to a far greater diversity of uses for bronze.



Figure 12: Bronze masks (hollow human heads) created using piece mold castings, excavated in the Sichuan province, late Shang period (1300 BC-1100 BC) [30].

As in the earlier period, craft tools, weapons and vessels dominate the archaeological record, but farming tools and even architectural elements including what may be a bronze door ornament (Figure 15) began to appear. New vessels (*zun*, *lei*, *yu*, *hu*, *li*, *yan*, *gui*, *pan* and *fang ding*) emerged in the early Shang sites in addition to those seen in Xia culture. Most of these were distinguished by their elegant shapes and their ornamentation (animal masks, cloud and thunder motifs, *kui* dragons). The levels of aesthetic achievement for these bronzes far exceed those of the previous Xia dynasty [2].

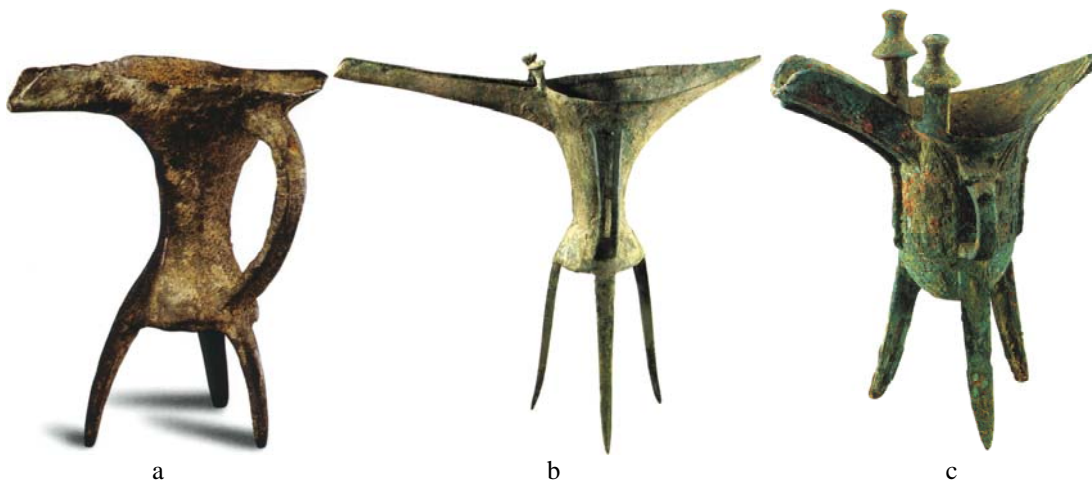


Figure 13: The vessels (*jue*) were used in complex ceremonies that involved drinking barley wine; **a)** this is one of the earliest cast bronze vessels from the Erlitou period, primitive in appearance; **b)** *jue* with long spout and tripod legs is another example of one of the oldest cast bronzes; **c)** forty of these vessels were found in the tomb of queen Fu Hao (Shang dynasty); bronzes were an indication of the rank and prestige of the deceased [13].

Shang culture gradually encroached upon other peoples, spreading from its central territory to yield a strong influence in the Shaanxi, Hubei and Hebei provinces. As a result, by the sixteenth and fifteenth centuries BC, the early Shang culture represented by the Erligang site had grown to be the most advanced and influential bronze culture in the eastern hemisphere [2].



Figure 14: Jue with flat base and taotie design, H: 14 cm; vessel features are characteristic of early Shang or Erligang: the short posts on the narrow spout, the thickened rim around and the mouth of the vessel [34].

Max Loehr in 1953 developed a technique for classifying the Shang bronze styles. Style **I** was found on a small range of vessel types, often poorly cast and decorated in thin relief lines. Style **II** included more vessel types, often very well cast and with distinct divisions of body parts and decorative zones. Style **III** expanded and elaborated elements of the previous phase with technical improvements in casting and more coherent designs. In Style **IV**, the vessel types and ornamental devices were greatly augmented. Loehr gave consideration to possible influences from other media, noting the inheritance of vessel types from black pottery of the late Neolithic Longshan culture and common decorative patterns from the white pottery of Anyang as seen in Figure 11g [6, 23]. It was thought that the early Shang ceramic techniques probably influenced the decoration of molds and models for bronze casting in the beginning stages of bronze vessel manufacture. In later stages of the Shang period (Anyang phase), style and techniques were interrelated between media (bone and wood carving, ceramic and bronze development). By the late Shang period, however, the ceramic industry had begun to decline [6, 23].

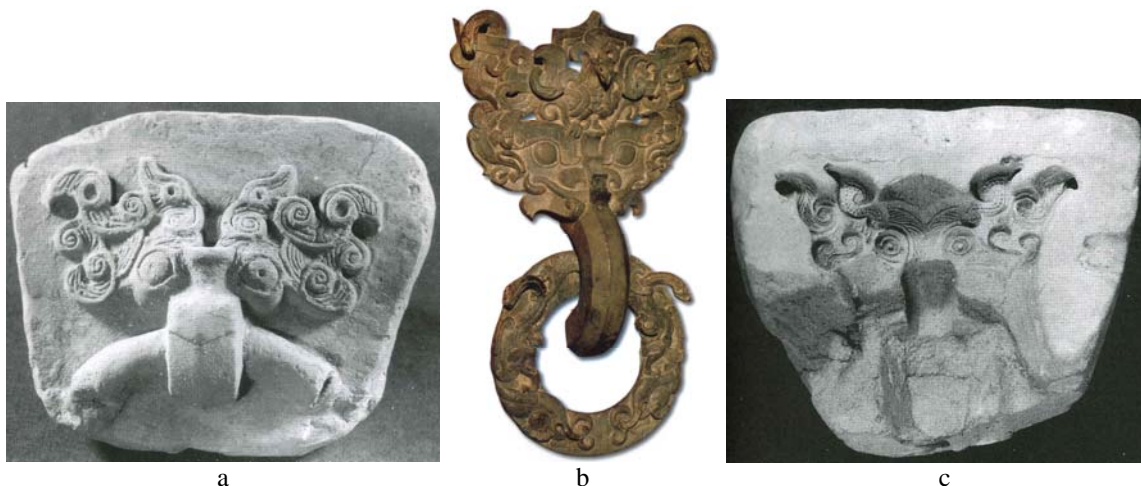


Figure 15: a) casting molds for handles or door rings (positive impression) [22, 23]; b) bronze animal-mask door ring; Warring States period, Hebei province [41]; c) negative clay mold impression found at the Houma Foundry [22, 23].

Clay Mold Production at Houma Foundry

A political center during the period (585 BC -376 BC), the Shanxi Provincial Institute of Archaeology has surveyed and excavated an area of nearly 40 square kilometers between the Fen and Hui Rivers, northwest of Houma in Shanxi province. The site comprised seven earth walled cities of various sizes, building foundations and bronze foundries, occupying approximately 200,000 square meters found [22, 43]. Excavations since 1959 have exposed one workshop, two kilns, 68 houses, 3 ash pits yielding over 50,000 molds and models (nearly 1000 of these were complete), large numbers of pottery vessels, smelting furnaces, wind pipes, and pieces of lead (Figures 15-18). At least 25 types of decorative motifs are evident in the models and molds, including dragons, phoenixes, animal masks, geometric patterns, human figures, birds, fish, and animals. The finds indicate that the bronze foundries produced tools, ritual vessels, horse and chariot fittings, daily commodities, musical instruments, and coins. The discovery of the bronze foundries led to the recognition of the Jin capital as the nucleus of bronze manufacture in northern China during the Eastern Zhou period [22, 43]. This capital, with its abundance and variety of cultural remains, is among the richest sources of excavated materials in China, providing comprehensive and systematic data for investigating bronze casting technology and styles [22, 43].



Figure 16: Pottery tiger mold found at bronze foundry site at Houma in Shanxi province, from Spring and Autumn period; L: 18.3 cm, H: 8 cm [44].



Figure 17: Pottery animal mask model for bell found at bronze foundry site at Houma in Shanxi province, from Spring and Autumn period, W: 32.8 cm, H: 22.5 cm [44].



Figure 18: Clay coin mold pieces found at Houma site [22, 23, 45].

Coins

The Chinese had a variety of objects that were used for money, from primitive cowries to round coins, spades and knife money (Figure 19). Many of the early coins found do not have proper provenances, and quite often their dates and mint locations are unknown. Most knife coins have the name of the mint and the town where they were minted, but in ancient times many of the towns had the same name. The earliest coin molds that have been found are spade and knife coin molds (from 770 BC-476 BC) that were carved in clay, stone or bronze. The inscriptions were carved (incised into) the clay molds and used for the actual casting. The clay molds could be used only one time (Figure 18), the stone and bronze molds could be used several times (Figure 20).



Figure 19: Coins from the Warring States period. Half-liang, the circular piece with a square hole in the upper left corner, is from the Qin state. The other money was used in the six other states (3 are spade coins, ant nose (smallest coin) and 2 knife coins). When the First Emperor united the country, he made the Qin half-liang coin the sole legal currency [46].

The clay molds were destroyed after the casting in order to release the coins. Soft stone molds were preferred to the clay molds; clay molds were time consuming to make and expensive considering they could be used only once. Hard stone would crack due to the high shift in temperatures during casting. Stone molds were not destroyed and had a shape that allowed the mold to be opened and used again. The early carved bronze molds could be used for the actual casting. The ant nose money was very simple with basic carved inscriptions, making it feasible to be directly cast in a carved bronze mold [9, 47]. The molds from the Han dynasty were baked before casting, and molds were likely also baked in earlier times, since the clay would probably crack during the casting, if they were only sun-dried.



Figure 20: The use of bronze dies instead of terracotta or stone molds to mint coins was introduced in the Warring States period. The molten metal was poured into the channel at one end, ran along and flowed into the side hollows (Qin period) [13].

Mining and Smelting at Tonglushan

Archeological excavations in the mining center of Tonglushan, Hubei Province revealed an enormous mine measuring approximately 2 kilometers from north to south and 1 kilometer from west to east. The site, near the Yangtze River (also known as Chang Jiang), contains copper mines and smelting foundries dating from the late Shang through the Western Han period. A copper smelting site was found in Zone XI (Figure 21a). The shaft furnace seems to have been equipped with ventilation grooves (in the base and tap hole) and blast inlets that used charcoal for smelting. The residue from the whole site totaled approximately 400,000 metric tons, and the thickest layer of residue measured more than 3 meters. Laboratory tests show that the slag had a copper content as low as 0.7 percent [44]. It has been estimated that more than 100,000 metric tons of raw copper were produced at the site. The findings suggest that both laborers and workshops for mining, smelting and casting were highly specialized, and that both mining and smelting techniques had already achieved a high level of complexity by the Eastern Zhou period.

Tonglushan is one of the 55 mining and smelting sites in this region and contains evidence of open cast and underground mining. The archaeological team while excavating six mining locations and two smelting sites (Figure 21b), discovered 231 shafts and winzes (connecting passageways), 100 horizontal and inclined walkways, 12 smelting furnaces and nearly 300 mining tools made of bamboo, bronze, iron, stone and wood [44]. The mine was equipped with facilities for water discharge, ventilation and a well pulley that enabled workers to mine material at 40 to 50 meters underground and to lift the raw ore up to ground level. Mining tools, including wooden shovels and hammers and bamboo baskets were found inside the tunnels.

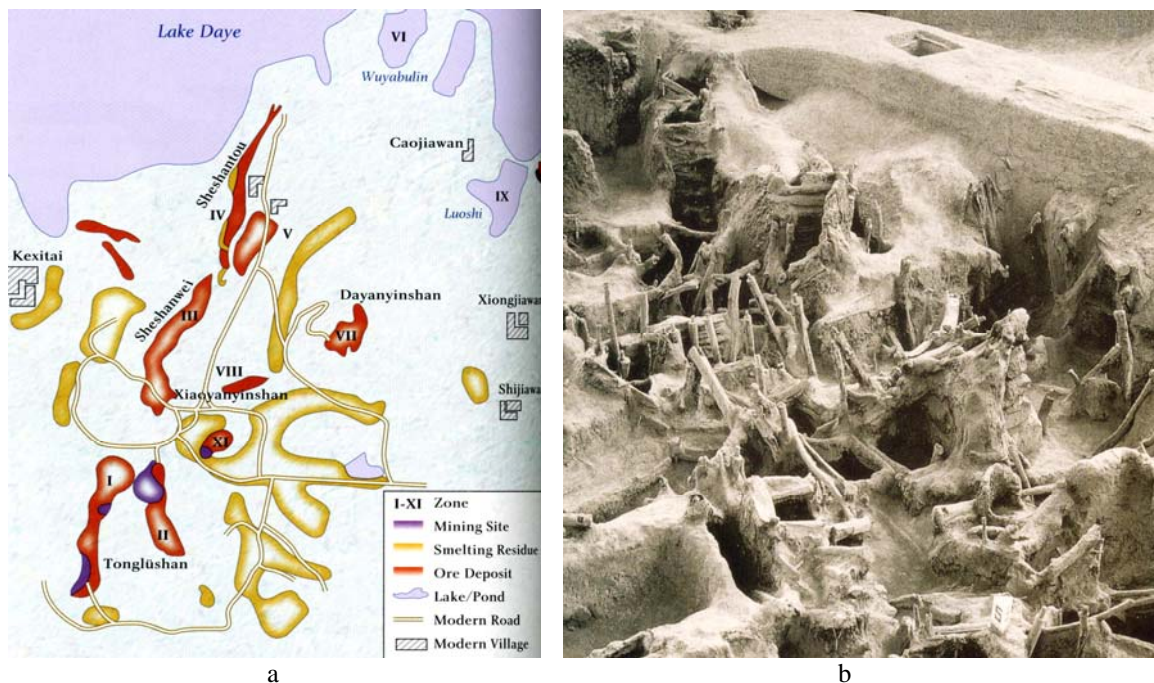


Figure 21: a) Distribution of mining and smelting localities at Tonglushan in Hubei province; b) mine remains discovered in 1973 and excavated from 1974 to 1985; more than 400,000 tons of ancient slag and high grade copper deposit were found here [44].

Further excavation unearthed tools made of bronze, iron, bamboo, wood and stone. Also uncovered were more than 100 separate diggings and dozens of smelting furnaces. The total length of the trenches and shafts has been estimated at 8,000 meters; this would result in roughly 80,000 to 120,000 tons of copper extraction from this area (Figure 22).



Figure 22: Example of copper ores that would have been mined by the ancient Chinese [48].

The discovery and excavation of the Tonglushan is of great significance for the study of bronze metallurgy and mining technology during the Shang and Zhou period [44]. Another large mining and smelting site in Jiangxi province, roughly 60 kilometers southeast of Tonglushan, was excavated during 1988 and 1991. Dating from the middle Shang to early Warring States period, the site's mining remains covered 70,000 square meters and copper smelting remains 200,000 square meters, with the thickness of residue ranging between 0.6 and 3.40 meters. This discovery further revealed that the region, (Hubei province and Jiangxi province) was a massive copper production center during Bronze Age China [44].

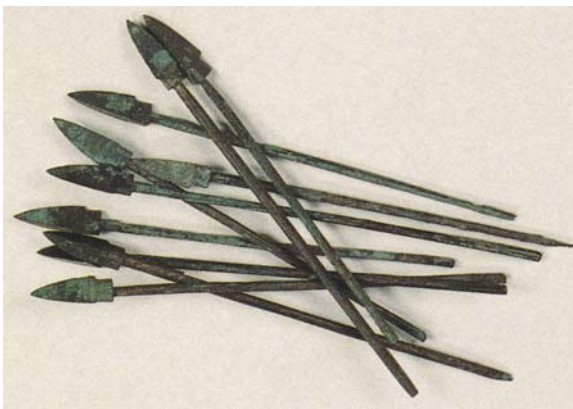
China's First Emperor

The Shang dynasty was the central power for approximately 600 years; the Zhou dominated for the next 850 years. During the period from 770 to 221, the Zhou dynasty was weakened by the constant fighting between the states (Warring States period). The state of Qin conquered the other states and founded a unified empire in 221 BC. Imperial China began with the Qin dynasty, and though it was short lived, it set the model for a unified and homogeneous state. The path to advancement in Qin society was through military service. Even those born into a prestigious family had to prove their loyalty and courage in military campaigns. King Zheng assumed leadership of the Qin in the year 246 BC at age thirteen and proclaimed himself Qin Shihuangdi (the First Emperor of Qin). The Qin state developed a strong, disciplined army that relied on the latest technologies. Bronze spearheads, arrowheads and crossbows are some of the weaponry unearthed in Shaanxi (Figures 23-24). Arrowhead tips were attached to bamboo shafts; more than 10,000 have been excavated near the terracotta soldiers. The crossbow had become a standard weapon by 5th century BC in China, more than 1200 years before it was seen in Europe [23, 49]. This Qin mechanized the crossbow with an attachment at the end of a wooden arm.



Figure 23: Bronze spearhead, L: 35 cm (13.6 in), excavated in 1976 from Pit No. 1 at the tomb of Qin Shihuangdi in Shaanxi; the surface of the spearhead is decorated with a cloud pattern, the blade has a hexagonal face [49].

Within several years of taking the throne, Shihuangdi launched a series of military campaigns that led to the defeat of all rival states. Until his death, he ruled the Chinese empire [1]. China's First Emperor built a huge mausoleum, a palace and court (below ground) that would provide for his afterlife, including an army of more than 7000 terracotta soldiers that stood in formation (Figure 25).



a



b

Figure 24: a) Bronze arrowheads, L: 17.2 - 20 cm (6.7 – 7.8 in), excavated in 1976 from Pit No. 1 at the tomb of Qin Shihuangdi [23, 49]; b) bronze crossbow mechanism, L: 8 cm (3.1 in), H: 16.2 cm (6.3 in) excavated in 1979 from Pit No. 1 [23, 49].

Despite the huge size of the terracotta army, individual figures showed great attention to detail. Mass production had not overshadowed a concern for individuality. The figures were made using molds in a number of standard types, with heads, hands and torsos in different combinations. Details of armor fittings, even the soles of shoes, were painstakingly recreated in ceramic form. Each figure had been brightly painted. Creation of this terracotta army was a massive undertaking [1].



Figure 25: a) In 1974, farmers drilling wells in search of water made the first finds of the underground army of Shihuangdi; b) the site has been under continuous excavation and restoration ever since [12].

Conclusion

It was believed that Chinese civilization developed in the Central Plains area of the Yellow River; only this area had been heavily excavated (in the 1950s) to prepare for a reservoir when the ancient sites of the Yangshao were unearthed. Since this first discovery, major excavations have been undertaken in areas thought to be lacking historical context or devoid of any cultural significance: such as Sichuan, Shaanxi, Shanxi, Hebei, Shandong, Henan, Chongqing and Hubei. It was assumed that bronze casting was not introduced to China by foreigners since cultures outside of China relied on significantly different metal working methods like hammering sheet metal. The Chinese were adept at manufacturing, creating and decorating ceramic clay vessels (as seen from the Neolithic cultures). It is believed that Chinese casting techniques were independently developed during the Shang dynasty or possibly as early as the late Xia.

The Chinese learned how to smelt copper and tin to make vessels, weapons and tools; this required an organized labor force and skilled craftsmen. The high level of workmanship seen in the bronzes in Shang tombs suggested a stratified and well organized society. Typically order was instilled through powerful rulers who mobilized human and material resources to mine, transport and refine ores, to manufacture the clay molds for casting and to run the foundries. Bronze became widespread in the central plain of China in early Shang times. A puzzling aspect about the quality of the Shang bronzes is their level of craftsmanship; there must have been an earlier bronze culture not yet discovered whose tombs were filled with poorly cast-primitive bronzes. Furthermore, casting large objects, as did the Sanxingdui culture, was not easy; it required large crucibles and efficient furnaces. The high temperatures of the Neolithic kilns used to fire pottery were hot enough to melt metals from stone; pottery kilns found near Xi'an could maintain

temperatures at 1400 °C as early as 5000 BC. Casting some of the largest objects required coordinated melting in many crucibles similar to a modern factory. But, casting was a more natural progression for the Chinese who had a long history with pottery and jade carving since the Neolithic period.

Chinese bronze artifacts at first were very similar to the pottery vessels, but soon evolved into shapes adapted to the bronze material. Bronze material attributes could acquire countless forms, possess strength and durability, demonstrate brilliant exteriors and musical precision, and serve as religious icons and weapons of war. The number and variety of vessel forms increased, as well as the complexity of decoration and manufacturing techniques. These developments occurred alongside improvements in casting technology; advances that included process planning, extracting, refining and bronze casting. Bronze alloys were used almost to the exclusion of any other alloy for nearly 1000 years in China, even after the introduction of iron. The evolution of casting technology and bronze metallurgy began well before the Bronze Age.

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